

### REMARKS/ARGUMENTS

Claims 1-5, 11 and 13-18 are active. Claims 7-10 have been withdrawn from consideration. New Claims 19-24 find support as follows: Claims 19-22 (Claim 1), Claim 23 (Claim 1, page 15 [0044]), and Claim 24 (Claims 1 and 7 and on the third line from the bottom of page 5 of the specification. Accordingly, the Applicants do not believe that any new matter has been introduced.

The Applicants thank Examiner Roe for the courteous and helpful interview on January 18, 2007. To help avoid the prior art rejections, it was suggested that the Applicants point out why the claimed range of interstitial elements (e.g., oxygen) would produce functionally different titanium alloys. Other limitations that would help avoid the prior art were discussed.

#### Document 2

##### 2. Present invention

(1) As for a titanium alloy of the present invention,  $MO_{eq}$  is far from that of the conventional titanium alloy comprising a  $\beta$  single phase. However, the present invention is based on the finding that, even from such titanium alloy, a titanium alloy comprising a stable  $\beta$  single phase can be obtained within the room temperature by increasing an oxygen content. The present invention is characterized in that oxygen is contained in large amount which is remarkably beyond the common knowledge in the field of the conventional titanium alloy (see paragraphs [0019]-[0024], [0046]-[0048] of the specification). Document 1 (Materials Properties Handbook: Titanium Alloys, attached) shows the common range of oxygen content of the conventional titanium alloy.

(2) The prior art publication concerning  $MO_{eq}$ , which was mentioned in your letter of January 26, 2007, is not available as a matter of course. However, the data (Document 2, Kim et al., Figure 1, attached) which shows the change of martensitic transformation point (Ms

point) concerning some composition (Ti-xNb) , and the data (Document 2, Kim et al., Figure 2, attached) which shows the change of Ms point of specific composition therein (Ti-22at%Nb-xO) are described in the article which was published after filing the present application. For your information, Ms point means the temperature at which a phase is changed to  $\beta$  phase.

When Ti-22at%Nb (without o) is converted from atomic% to mass% to be applied to the  $MO_{eq}$  equation,  $MO_{eq}$  is approximately 10, which is within the present invention. Furthermore, according to Figure 1, Ms point of Ti-22at%Nb is approximately 420K, which is remarkably higher than the room temperature (approximately 290K). Due to this, even if  $MO_{eq}$  is from 3 to 11, which is within the present invention, a 13 single phase titanium alloy which is stable at around the room temperature (like a titanium alloy of the present invention) cannot be obtained.

The biggest point of the present invention is to find that, even from a titanium alloy having  $MO_{eq}$  which cannot be a  $\beta$  single phase within the room temperature naturally, a titanium alloy comprising a  $\beta$  single phase can be obtained within the room temperature by increasing an oxygen content to the range which is remarkably beyond the common knowledge.

The mechanism which has been resolved after filing the present application is shown in the attached Figure 2. Figure 2 shows that Ms point is lowered by increasing oxygen. When the oxygen content is converted from mass% to atomic%, the lower limit of oxygen content, namely 0.6 mass%, is 2.0 atomic%, and Ms point is lowered from 420K to approximately 100K ( $420K - 320K = 100K$ ). This temperature (approximately 100K) is remarkably lower than the room temperature. Therefore, it is apparent that the above titanium alloy (as one alloy of the present invention) is a titanium alloy which has a  $\beta$  single phase satisfactorily at around the room temperature, contrary to the conventional titanium alloy.

(3) The lower limit of oxygen content which is shown in the present invention is determined in consideration of Saito et al. (US6,607,693B1), and it is difficult to show the critical meaning thereof strictly in view of the effect. This is understandable from the attached Figure 2 which has been apparent after filing the present application. However, we think that the critical meaning of  $MO_{eq}$  is almost shown in Table 1 of the specification.

By paying attention to this matter, please argue the Examiner in all effort.

(4) We add some explanation about each alloy listed in Table 1 of the present invention.

Test pieces No. 1 to No. 4 are within the claims of the present invention, and they exhibit low Young's modulus and high tensile strength without generating stress-induced transformation.

On the contrary, test pieces No. 5 to No. 7 as comparative alloys don't satisfy a part of claims of the present invention. As for test piece No. C1,  $MO_{eq}$  is above 11, and Young's modulus is high. As for test piece No. C2,  $MO_{eq}$  is less than 3, and a phase exists after solution treatment to show high Young's modulus. As for test piece No. C3,  $\alpha''$  exists after solution treatment because of low oxygen content, and stress-induced transformation is generated in elastic deformation field.

#### Restriction/Election

The Applicants previously elected Group I (products) with traverse. Group II, claims 7-10 (process) have been withdrawn from consideration. The requirement was previously made FINAL. The Applicants respectfully request that the claims of the nonelected group which depend from or otherwise include all the limitations of an allowed elected claim, be rejoined upon an indication of allowability for the elected claim, see MPEP 821.04.

Rejection—35 U.S.C. §103

Claims 1-5, 11, 13 and 15-17 were rejected under 35 U.S.C. 103(a) as being unpatentable over Bitter et al., GB 2,190,100. Bitter et al. do not render the invention obvious, because they do not disclose or suggest the 0.6 to 3% by mass interstitial element (e.g., oxygen) content required by the invention, nor do they exemplify the  $\beta$  single phase alloys of the invention which are stable at room temperature.

While page 2, line 11, of Bitter refers to interstitial elements, such as nitrogen, carbon and oxygen, there is no disclosure or suggestion of the 0.6 to 3% by mass range required by independent Claim 1. There is no disclosure or suggestion in Bitter for  $\beta$  single phase titanium alloys stable at room temperature containing this large content of an interstitial element such as oxygen. On the other hand, as described in the specification starting at the bottom of page 4:

The inventors of the present invention have. . . discovered a novel fact. Namely, even when titanium alloys have a composition exhibiting a relatively low “Mo<sub>eq</sub>” which have been regarded as the unstable regions of  $\beta$  phase, it is possible to produce  $\beta$  single phase titanium alloys which are stable even at room temperature by including oxygen in a large content.

An important aspect of the present invention is the discovery that, even from a titanium alloy having Mo<sub>eq</sub> which cannot naturally be a  $\beta$  single phase at room temperature, a titanium alloy comprising a  $\beta$  single phase at room temperature is obtained by increasing an oxygen content to the range which is remarkably beyond the common knowledge.

As shown by the attached Fig. 1 from Kim et al. (2005), the temperature point at which  $\alpha$  phase changes into  $\beta$  phase (“the martensitic transformation point” or “Ms point”) indicates that even if Mo<sub>eq</sub> ranges from 3 to 11, which is within the present invention, a  $\beta$  single phase titanium alloy which is stable at room temperature cannot be obtained. Fig. 1 (attached) shows that the Ms point of Ti-22at%Nb is approximately 420K, which is remarkably higher than room temperature.

Fig. 2 (attached, and published after this application's filing date) shows that the change in the Ms point of the composition Ti-22at%Nb-xO is lowered by increasing oxygen content. As shown, when the oxygen content is converted from mass% to atomic%, the lower limit of oxygen content, namely 0.6 mass%, is 2.0 atomic%, and the Ms point is lowered from 420K to approximately 100K ( $420\text{K} - 320\text{K} = 100\text{K}$ ). This temperature of approximately 100K is remarkably lower than room temperature. Therefore, it is apparent from these data that the titanium alloy according to the invention is an alloy with a single  $\beta$  phase at room temperature, and thus is distinguishable from the conventional titanium alloy, which is not.

The present invention is characterized in that oxygen is contained in large amount which is remarkably beyond the common knowledge in the field of conventional titanium alloys--see paragraphs [0019]-[0024], [0046]-[0048] of the specification. Document 1 (attached) shows the common range of oxygen content in conventional titanium alloys.

There is simply no suggestion in Bitter et al. to produce or select such an alloy, nor any reasonable expectation of success that the alloy of Claim 1 would be stable at room temperature despite an interstitial (e.g., oxygen) content of 0.6 to 3.0% by mass.

While Bitter concretely describes three kinds of titanium alloys in Figures 1 and 2 and claims 9-11), the  $\text{MO}_{\text{eq}}$  for each of these alloys is outside of the present invention (as apparent by calculation based on the  $\text{MO}_{\text{eq}}$  equation). Furthermore, these titanium alloys are typical titanium alloys comprising  $\alpha + \beta$  phase, not  $\beta$  single phase as in the present invention. While page 3 of the Official Action refers to a titanium alloy containing 3% Mo and 3% Va as providing an  $\text{MO}_{\text{eq}}$  of 5 based on the  $\text{MO}_{\text{eq}}$  equation, this is not material, since there is no direction in Bitter et al. to select such a combination, nor any suggestion that such a combination should contain 0.6 to 3.0% by mass oxygen (or the other interstitial elements). Furthermore, as discussed below, one of the other prior art references, Ahmed et al.,

specifically teaches away from including a content of more than 0.5 % by mass in a titanium alloy. Thus, as discussed above, Bitter provides no suggestion or motivation to include the required interstitial element content, nor any reasonable expectation of success that this combination would provide the  $\beta$  single phase titanium alloys stable at room temperature. Accordingly, the Applicants respectfully request that this rejection be withdrawn.

Rejection—35 U.S.C. §103

Claims 1-5, 11, 13 and 15-18 were rejected under 35 U.S.C. 103(a) as being unpatentable over Saito et al., U.S. Patent No. 6,607,693. Saito does not render the invention obvious, because it does not disclose or suggest a  $\beta$  single phase alloy that is stable at room temperature as required by independent Claim 1. This is understandable from the fact that solution treatment is not carried out in Saito et al. while solution treatment is carried out in the present invention. There is no suggestion or motivation in Saito for producing the alloy of the invention which is a  $\beta$  single phase at room temperature, nor any disclosure (or reasonable expectation of success) of how to obtain such an alloy. Thus, Saito does not enable the present invention, suggest making the  $\beta$  single phase alloy of the invention, nor provide a reasonable expectation of success for obtain this  $\beta$  single phase alloy.

While Saito describe that the upper limit of oxygen content is 0.6 mass %, there is no concrete example in which oxygen content is 0.6 mass %. Namely, in Saito, the example which shows the largest oxygen content is test sample No. 46 in Table 4, but actually, the oxygen content is 0.57 mass %. Thus, Saito does not exemplify any compounds which anticipate or render the invention obvious. Accordingly, the Applicants respectfully request that this rejection be withdrawn.

Rejection—35 U.S.C. §103

Claims 1-5 and 11 were rejected under 35 U.S.C. 103(a) as being unpatentable over Ahmed et al., U.S. Patent No. 5,671,595. Ahmed does not disclose all the elements of the invention, namely, composition in which the interstitial solution element ((O, N, C) content is between 0.6% and 3% by mass. In Ahmed the upper limit of oxygen content is 0.5 mass, and this doesn't overlap the lower limit of interstitial element content of the present invention. The Office has applied no art which indicates that the claimed range and the prior art ranges are functional equivalents.

In fact, Ahmed teaches away from the present invention because col. 5, line 4 specifically indicates that “the alloys of this invention **should not** exceed 0.5% by weight” of the non-toxic interstitial elements. The argument in the Official Action that the prior art range and the present claimed range of interstitial elements are “functional equivalents” is specifically controverted by this section of Ahmed.

Furthermore, in Ahmed et al., there is no description that a  $\beta$  single phase titanium alloy which is stable at around the room temperature, as in the present invention, can be obtained and solution treatment is not carried out.

Accordingly, Ahmed does not anticipate the invention, nor can it render it obvious in view of the lack of any motivation to employ the range of interstitial element content of the invention and its specific teaching away from this content. Accordingly, the Applicants respectfully request that this rejection be withdrawn.

Rejection—Double Patenting

Claims 1-5 were rejected under the judicially-created doctrine of obviousness-type double patenting as being unpatentable over claims 1, 2, 5, 6 and 26 of Saito et al., U.S. Patent No. 6,607,693.

Claim 26 of Saito is a process claim and not pertinent to pending product Claims 1-5. With respect to Claims 1, 2, 5 and 6 of Saito, none of these claims require an alloy which is “ $\beta$  phase at room temperature”. This limitation clearly distinguishes the claimed subject matter from that of Claims 1, 2, 5 and 6 of Saito which does not specify  $\beta$  phase. Clearly, a  $\beta$  phase alloy is distinguishable from an  $\alpha$  phase or mixed  $\alpha + \beta$  phase alloy. Claims 1-5 are distinguishable from the prior claims, since the prior claims are not limited to  $\beta$  phase alloys.

Moreover, as discussed above, in Saito et al., there is no description that a  $\beta$  single phase titanium alloy which is stable at around the room temperature, as in the present invention, can be obtained. This follows from the fact that solution treatment is not carried out in Saito et al. while solution treatment is carried out in the present invention. Accordingly, the Applicants respectfully request that this rejection be withdrawn, since Claims 1-5 are patentably distinct from the claims of Saito.




Conclusion

In view of the above amendments and remarks, the Applicants respectfully submit that this application is now in condition for allowance. An early indication of such is earnestly requested.

Respectfully submitted,

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